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Microbial Biomass Changes in the Forest Floors of Kashmir Valley

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ABSTRACT

Monitoring of biomass changes in the forest floors is necessary to predict long-term impact of deforestation on soil health. Biomass-C changes were monitored over a period of 13 days of incubation by chloroform fumigation method. There was a net increase in the total microbial biomass in the soil with inherent forest floors. Biomass-N levels ranged from 31.25 mg kg^{-1} soil in Shankeracharya forest soils to 98.40 mg kg^{-1} in Dachigam forest soils. Degradation of deforested soils manifests in lower biomass of C and N.

Key words: Biomass, carbon, forest, nitrogen

INTRODUCTION

Microbial biomass responds immediately to alterations in soil ecosystem and thus its measurement is a viable tool for understanding and predicting long-term impact of deforestation (Powelson *et al.,* 1987). Plants add energy to the soil system in the form of litter and root exudates which eventually are turned into soil microbial biomass that is a major pool responsible for nutrient cycling and for controlling amounts of nutrients available to plants (Ohtonen *et al.,* 1999). In forest environment experiments have documented nutrient limitation for tree growth in boreal, temperate and tropical forests due to deforestation (Heilman and Gessel, 1963; Baker *et al.,* 1994). Ecosystems that receive chronically low inputs of limiting nutrients in the form of litter eventually lead to low degree of nutrient cycling. The importance of biotic regulations of nutrient cycling has been demonstrated for temperate deciduous forests, coniferous forests and grassland (Reichle *et al.,* 1981). In the last fifty years deforestation has accelerated in Jammu and Kashmir as a result of poor government control, lack of local awareness, etc. (Anonymous, 2002). Consequently, closer monitoring of forest floor degradation has been necessary. This might be improved by extensive study of soil biomass, which may provide early warning signals of ecological disturbance (Hobbie *et al.,* 2002). A maiden attempt was made to assess the effect deforestation on the change in nature of soil microbial biomass in terms of C and N in the Kashmir division of J&K.

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MATERIAL AND METHODS

Forest floor (F) and deforested soils (DF) area from each presurveyed locations: namely Shankeracharya (S), Dachigam (D), Ganderbal (G), Kangan (K), Handwara (H) and Tangmarg (T) were selected for soil sampling (Table 1). The samples were taken from the humus layer through a depth of 3 cm at 20 cms intervals at 100 m^2 quadrat. Soil samples were pooled for each quadrat and material was homogenized and stored (without sieving) before analysis. Soil water content was determined gravimetrically after drying sub samples at 105^0C for 12 h. For biomass analysis, soils were moistened immediately before analysis to a 250 percent water content of organic matter [which is reported to be optimal for microbial respiration in forest soil (Nordgren *et al.,* 1988)] and fumigated for 24 hrs with chloroform in vacuum desiccators. After fumigation, samples were incubated with 0.5 g fresh soil, placed in 1 litre airtight glass jar and incubated at 25± 1^0C for a period of 60 days. Controls consisting of 20.5 g sub soil samples were also incubated alongside the fumigated samples. Accumulation of CO_2 was assessed as absorbed in standard alkali. Biomass N was determined by extracting incubated samples by 2M KCl. Biomass C and N were calculated by equation $B=FC/K_c$ or K_n where B is total biomass of C and N, whereas K_c for biomass C was taken as 0.45 and for K_n for biomass N was taken as 0.54, and FC is difference of CO_2–C evolved from fumigated and unfumigated soil sample. Total N, using micro-Kjeldahls procedure (Bremner, 1965), total organic carbon using the wet digestion procedure (Allison, 1960) and humus layer thickness was measured by exposing soil profile.

RESULTS AND DISCUSSION

Soil microbial biomass is an index of microbial activities in soil, which is small, but highly labile pool influenced by deforestation. Changes in Biomass-C were monitored over a period of 60 days which showed a range of 100-250, 40-750, 210-877, 100-480, 150-650, 30-520, 175-812, 25-400, 200-910, 76-600, 210-765, 35-502 in the sites SF, SDF, DF, DDF, KF, KDF, HF, HDF, TF and TDF respectively (Fig 1). Biomass C values in all the sites were significantly different. During the incubation peak amount of biomass-C values were obtained for initial 13 days only, which was in contrast to the observations made by Jenkinson and Powlson (1976).

In all deforested locations biomass-C declined substantially and the extent of decrease was between 37 percent and 50 percent over corresponding forest floors. The contribution of biomass-C to total organic carbon was in the range of 1.38 to 3.12 percent. Biomass-N values in forest floors ranged from 31.25 mg kg^{-1} soil in Shankerachaya forest soil to 93.40 mg kg^{-1} in Dachigam forest soil. Deforestation has shown significant decrease in biomass–N at all sites. Changes in biomass-N were monitored only up to 7 days period.

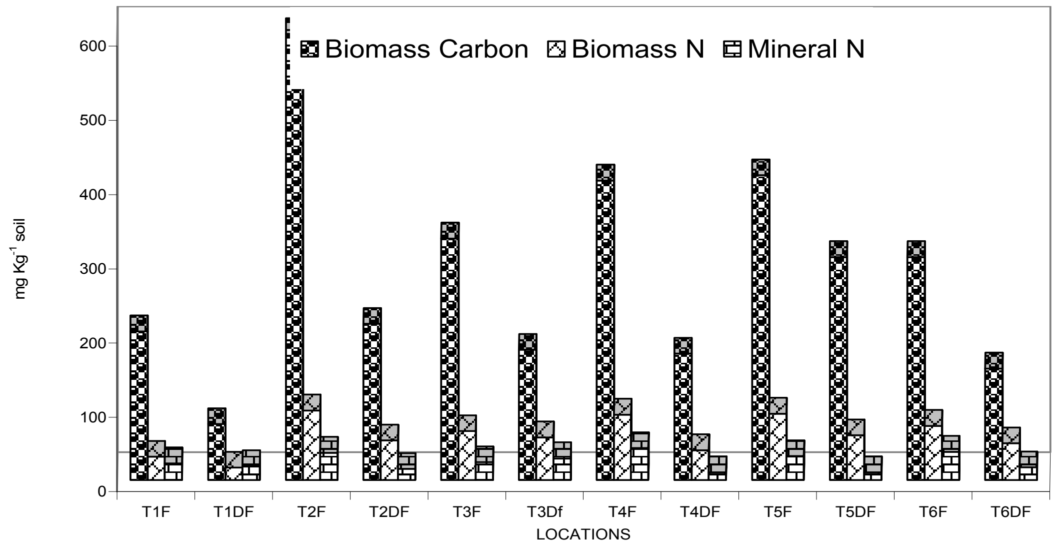

Fig :1 Impact of deforestation on microbial biomass C,Biomass-N and mineral-N

At all the sites, deforested soils have lost both biomass C and N substantially. The over all relationship between soil organic carbon content (x) and biomass-C (y) during 13 days period of incubation in 12 soils can be represented as Y=0.02X-2.2 [r0.85, significant at 5 percent level]. Results indicate that supply of organic matter from tree is generally larger because of the availability of litter. Thus small size of biomass C in deforested soil may be due to the lesser production of soil microbes per unit of substrate or less longevity of biomass synthesis due to the absence of quantum of plant biomass (Jenkinson and Ladd, 1989). Another reason for low biomass-C in deforested soil may be due to the decrease in detritus in area and creation of active fraction recalcitrant to decomposition due to the reaction with lignin, phenols, etc.

In comparing ratio of biomass-C to total organic C (microbial quotient, Fig 2) it was found to be significantly higher in forest floors (1.03-1.95%) than in deforested soils. Microbial biomass contributed 4.92 to 8.92 percent of total N in forest floors, whereas in deforested soils such contribution was 2.85 to 7.77 percent. Clearing of forest induces lower equilibrium of soil organic matter because of reduced organic input. It has been observed that decrease in organic C due to the forest clearing may lead to changes in the magnitude of biological and physico-chemical properties of soil (Martin *et al.*, 1991). The changes in soil pH of forest floors and deforested soils recorded a difference of 0.10 to 0.80 units (Table 1). The pH of forest floor was invariably lower than corresponding deforested soils, which might be due to the release of H^+ from organic acids originating from litter decomposition. It has been observed that percent base saturation may differ by more than 40 percent hence affecting pH (Binklay and Gardina, 1998).

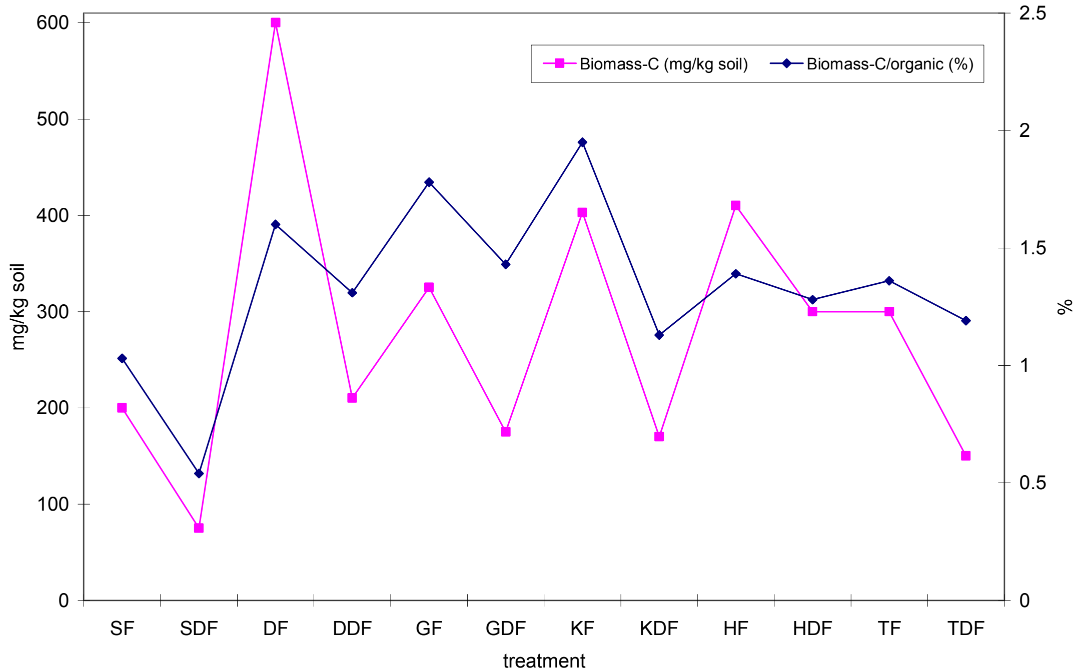

Fig. 2. Estimated variables of biomass

The above findings provide clear indication that deforestation might cause degradation of soils as the soils generally improve in suitability for supporting plant growth over a pedogenic time. Soil development typically includes accumulation of organic matter and nutrient, development of soil structure and development of sustained supplies of nutrients through a microbial activity. The matter and energy processed by earlier generation of plants and soil organisms result in a state of negative entropy which can benefit later generations.

The environmental variables for forest floors and deforested soils were compared with altitude (Fig. 3). The thickness of humus layer across altitude didn't show any positive correlation but deforestation led to significant reduction in humus layer. The extent of reduction ranged from 54.35 percent in Dachigam deforested soil to 74.36 percent in Kangan deforested soils, decrease observed was 48.57 percent in Shankerarchraya deforested soil to 48.51 percent in Dachigam deforested soil. The variations in the thickness of humus layer and consequently variations in the amount of organic C override most of the variations in biomass C and biomass N. Calculations of biomass-C to biomass N ratios, which reflect the decomposability of litter (Kaye and Hart, 1997), showed the values ranging from 8 to 10 indicating that microbial C: N ratios stabilized in all the soils despite of resilience. Obviously problems can arise in afforestation because under nutrient deficient condition in pine forests particularly organic N (the main nitrogen pool) is bound in recalcitrant compounds and shall be inaccessible to plants (Nasholm *et al.*, 1998). That is perhaps the reason why the rehabilitation and upgrading of the degraded forest soils and afforestation of barren area are colossal tasks in the Kashmir valley (Fotidar, 1989).

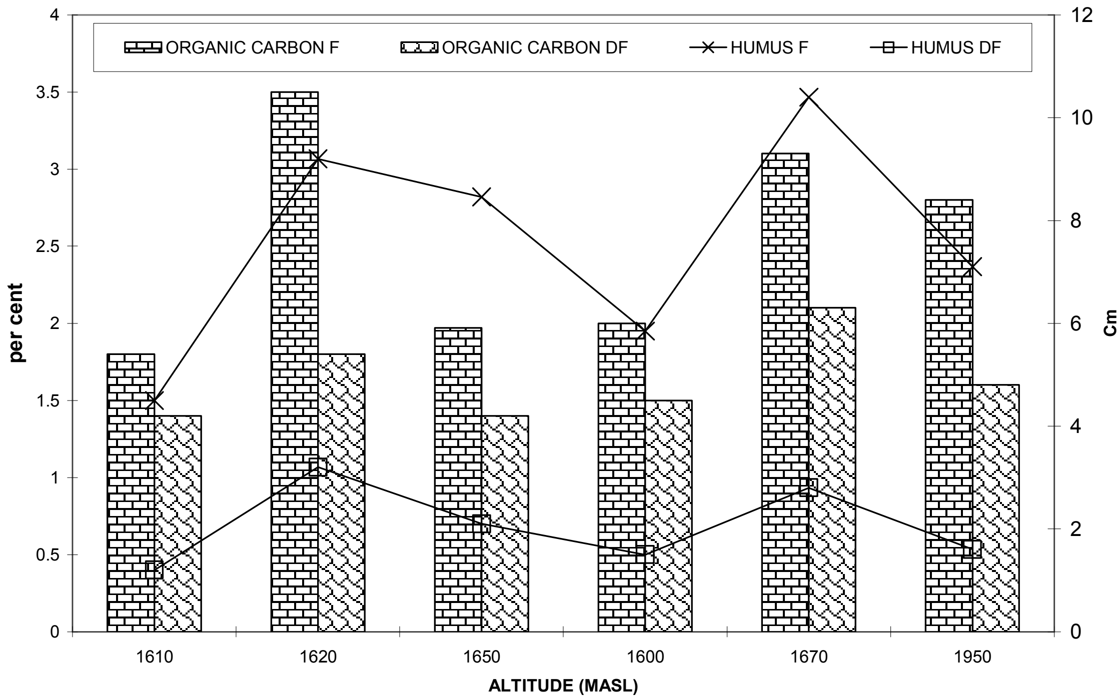

Fig 3. Effect of altitude on carbon transformation in forest floors

In the present study we have not determined the C to N ratio of detritus, which has effect on decomposability. But data suggest that the C: N ratio of detritus must have been higher than critical values for microbes, suggesting N limitation amongst decomposers as is evident in deforested soils where there is low microbial biomass N. A continuous monitoring of bio indicators shall serve as important basis for the future planning of the afforestation of degraded lands.

Table 1: Site characteristics of forest floors

Site	Forest community	Soil texture	pH	Organic carbon (%)	Total N (ppm)	Humus layer (cm)
Shankaracharya(F)	(Rubinia pseudoacia)	Silty loam	6.80	1.80	545	4.5
Shankaracharya DF)	Cupressus torulosa Cedrus deodara		7.10	1.40	540	1.2
Dochigam (F)	Pinus Walliachiana	Fine loam	6.10	3.50	784	9.2
Dachigam (DF)			6.90	1.80	784	4.2
Ganderbal(F)	Abies Pindrow	Silty clay	7.00	1.97	737	8.46
Ganderbal (DF)			7.20	1.40	736	2.10
Kangam (F)	Pinus Wallichiana	Silty loam	6.90	2.00	1400	5.85
Kangam(DF)	Abies Pindrow		7.10	1.50	1400	1.50
Handwara (F)	Cedrus deodara	Loamy	6.20	3.10	1374	10.4
Handwara (DF)	Pinus wallichiana		6.90	2.10	1300	2.8
Tangmarg (F)	Pinus wallichiana	Silty loam	6.30	2.80	1478	7.1
Tangmarg(DF)	Abies pindrow		6.00	1.60	1450	1.6

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